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Fine ceramics (advanced ceramics, advanced technical ceramics) — Methods of tests for reinforcements — Determination of the tensile properties of ceramic filaments at elevated temperature in air using the hot grip technique

Céramiques techniques — Méthodes d'essais pour renforts — Détermination des propriétés en traction des filaments à température élevée par la technique des mors chauds

FDIS stage

Edited DIS - MUST BE USED FOR FINAL DRAFT

Contents

Foreword

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This document was prepared by Technical Committee ISO/TC 206, *Fine Ceramics*.

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Field Code Changed

Fine ceramics (advanced ceramics, advanced technical ceramics) — Methods of tests for reinforcements — Determination of the tensile properties of ceramic filaments at elevated temperature in air using the hot grip technique

1 Scope

This document specifies a test method for determination of tensile properties, such as tensile strength, Young's modulus, and fracture strain of ceramic filaments at elevated temperature in air using the hot grip technique. This document applies to continuous ceramic filaments obtained either from a multifilament bundle or spool. This document does not apply to ceramic filaments with creep behaviour at test temperature. The hot grip technique is limited by the temperature resistance of the current ceramic adhesive.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 10548, *Carbon fibre — Determination of size content*

ISO 11567, *Carbon fibre — Determination of filament diameter and cross-sectional area*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ISO 19634, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Ceramic composites — Notations and symbols*

IEC 60584-1, *Thermocouples — Part 1: EMF specifications and tolerances*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19634 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/ https://www.electropedia.org/

3.1 3.1

gauge length

L_0

initial inner distance between tubular grips glued to fibre ends at room temperature

[SOURCE: ISO 19630:2017, 3.1]

3.2 ~~3.2~~
initial cross-section area
S_0
initial area of the cross section of the filament within the *gauge length* ~~(3.1)~~(3.1) determined at room temperature

[SOURCE: ISO 19630:2017, 3.3, modified — ~~definition has been revised,~~ "determined at room temperature" ~~has been~~ added to definition.]

3.3 ~~3.3~~
maximum tensile force
F_m
highest recorded tensile force on the test specimen when tested to failure

[SOURCE: ISO 19630:2017, 3.4.]

3.4 ~~3.4~~
tensile strength
σ_m
ratio of the *maximum tensile force* ~~(3.4)~~(3.4) to the *initial cross-section area* ~~(3.2)~~(3.2)

[SOURCE: ISO 19630:2017, 3.6]

3.5 ~~3.5~~
total compliance
C_t
inverse of the slope in the linear part of the force/displacement curve

[SOURCE: ISO 19630:2017, 3.8]

3.6 ~~3.6~~
load train compliance
C_l
ratio of the displacement, excluding any test specimen contribution, to the corresponding force during the tensile test

[SOURCE: ISO 19630:2017, 3.9]

3.7 ~~3.7~~
strain
ε
ratio of the longitudinal deformation to the *gauge length* ~~(3.1)~~(3.1)

[SOURCE: ISO 19630:2017, 3.10]

3.8 ~~3.8~~
fracture strain
ε_m
strain at failure of the test specimen

[SOURCE: ISO 19630:2017, 3.11]

3.9 3.9
elastic modulus
E
slope of the linear part of the tensile stress-strain curve

[SOURCE: ISO 19630:2017, 3.12]

4 Principle

For the hot-grip technique, the ends of a ceramic filament are bonded to two ceramic tubes by using adhesive with high temperature resistance at test temperature. The ceramic filament specimen is heated to the test temperature in air and loaded in tension at a constant displacement rate by a suitable mechanical testing machine until failure.[5]-[9].[5]-[9] The tensile force and cross-head displacement are measured and recorded.

The tensile strength is calculated from the force (F_m) and the initial cross-section area (S_0).[1]-[4]).[1]-[4]

The Young's modulus is calculated from the gauge length (L_0), the initial cross-section area (S_0), the total compliance (C_t), and the load train compliance (C_l).

For non-oxide ceramic filaments, in any case, the test results can include the potential effects of oxidation. The detailed test procedure shall be agreed between the parties and recorded in the test report.

NOTE1 Tests for the determination of tensile properties for non-oxide ceramic filaments at high temperature in air atmosphere differ from those in inert atmospheres. Contrary to an inert atmosphere, damage in an oxidative atmosphere accumulates due to the influence of applied stress and chemical effects of the material's oxidation.

NOTE2 Creep, thermal decomposition, and grain growth of filaments can occur during tensile testing at elevated temperature. These phenomena are temperature and time dependent. Therefore, the tensile properties obtained can vary depending on the heating profile, temperature holding time prior to loading, and loading rate.

5 Apparatus

5.1 Tensile testing machine

Tensile testing machine shall operate at a constant cross-head displacement rate. The force-measuring system of the testing machine shall be in accordance with ISO 7500-1, class 1 or better. The testing machine shall be equipped with a system for measuring the cross-head displacement with accuracy better than 1 µm.

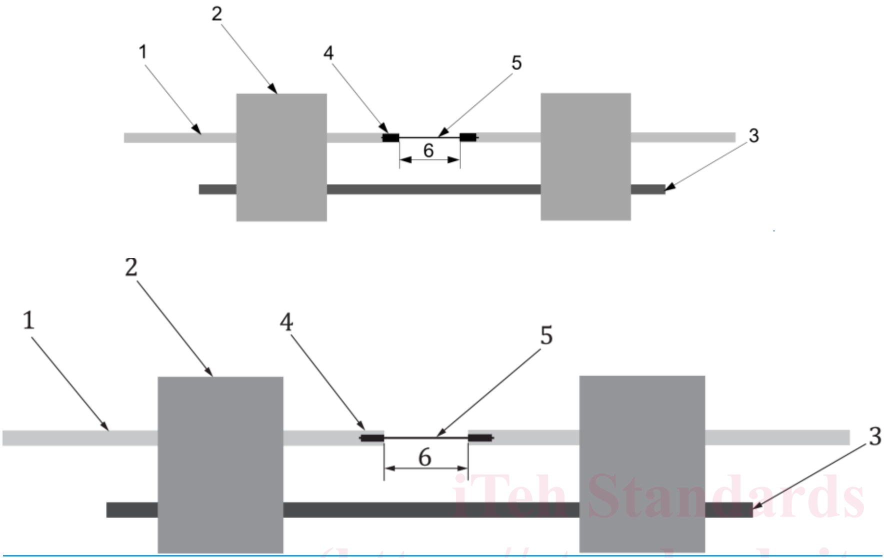
5.2 Grip system

The grips shall align the test specimen with the direction of the force. Slippage of the ceramic tubes in the grips shall be prevented.

5.3 Specimen holding device

The specimen holding device, including the ceramic tubes, the fixture block, and the guide bar, shall hold the ceramic filament and ceramic tubes together (see Figure 1)Figure 1) and assist with the installation of the specimen to the grip system.

Alumina ceramic tubes with (1 to 1,5) mm inner diameter and (2,5 to 3,5) mm outer diameter are recommended. An oblique cut in one end of the tube (see Figure 2)Figure 2) facilitates gluing of the ceramic filament to the tube. After machining, about half of the end is left. The length of the cutting slot in ceramic tube is about (5 to 10) mm.



Key

1 ceramic tube

2 fixture block

3 guide bar

4 gluing region

5 ceramic filament

6 gauge length

Figure 1 — Test specimen assembly